U.S. Department of Agriculture Agricultural Research Service
December 1981

Agricultural Research

An Investment in the Future

Returns from prudent investments in agricultural research continue to accrue year after year. But research administrators in the public sector, particularly, must husband resources and invest even more wisely if this nation is to match the rate of food production with that of demand.

We must be even more aware of investments we make in relation to those of state and private institutions. As a Federal sector research administrator evaluating our priorities, I see our agency moving toward more long-term, high-risk research of a fundamental nature and broad scope. This will allow private institutions to marshall their resources toward solutions that offer more immediate impact and that yield an acceptable return on investment.

The constraints and challenges are real. The risks and stakes are high. But I am confident that scientists and administrators in the agricultural research community have the vision and dedication to overcome the constraints and to meet the challenges ahead. I am confident of this because of our talents and our record as a leading research agency.

We should consider three recent research achievements in light of the challenges ahead. All will have or have had a direct impact on future food supplies and all offer a direct return on investment in agricultural research.

Scientists at our Plum Island Animal Disease Center, in cooperation with scientists at Genentec Inc. in California, developed a vaccine against one of the seven strains of virus that cause foot-and-mouth disease of ruminants. This vaccine will have major impact in nations where the disease exists or where it may occur in the future, including the United States. And the genetic engineering techniques used open the door to vaccines against the six remaining strains of foot-and-mouth disease as well as other animal diseases.

Federal and state scientists at Madison, Wis., transferred a gene for a storage protein from a French bean seed to cultured tissue of the sunflower plant. This is the first such transfer of a specific gene from one plant species to another. The challenges now are to convert the cultured tissue into a plant that will bear seed and to discover what effect the gene for protein storage of a bean has on the composition of a sunflower seed. This discovery, also based on genetic engineering, is part of a long-range, basic investment. It offers scientists in all sectors of our research community another tool with which to increase the nutritive value of plants, to create plants resistant to disease and environmental stress, or to make them capable of fixing nitrogen from the air. But improvements of this nature are very complex, requiring many genetic engineering steps with known as well as unknown barriers to be overcome.

Scientists at our Regional Poultry Research Laboratory at East Lansing, Mich., have successfully vaccinated chick embryos against Marek's disease 3 days before they hatched and have also developed a new combination vaccine that controls the more virulent strains of Marek's disease in chickens. (See pages 5 and 6 in this issue.)

The recent discoveries at the East Lansing laboratory hedge investments made in research there during the 1960's. The discoveries also ensure that returns from those investments of the 1960's will continue to accrue, year after year, from the research that developed the original vaccine against Marek's disease.

In 1971, the first year the Marek's disease vaccine was available for use nationally, benefits to the poultry industry amounted to $30 million. Cost of the research was about equal—$32 million over 10 years. In 1974, the first full year industry adopted the vaccine, gross benefits climbed to $628 million. In less than 3 years after the vaccine became fully available, it had been accepted by 95 percent of the industry. That compares with 7 years for hybrid corn to be adopted in Iowa and 36 years for hybrid corn to be adopted throughout the United States.

Projected savings to poultry producers are $2 billion by 1983 from reduced deaths and condemnations of poultry and from improved feed use and increased egg production. As a result of these savings, both eggs and poultry meat can be produced less expensively, which means lower cost, better quality products for consumers.

Research results such as these represent extraordinary returns on investment, returns that are not typical, of course. Not all research investments carry guarantees of direct returns, particularly investments in long-range, basic research. However, a review by Mississippi State University of about 20 national studies shows the average annual return on investments from agricultural research to be between 30 and 50 percent. Even a 30-percent annual return on the dollar is extraordinary. We in agricultural research can be confident of reaching and maintaining that average, because the needs are clear, the ideas are forthcoming, and our capabilities and resolve are strong.

Terry B. Kinney, Jr.
Acting Administrator, ARS

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Acting Editor: Virginia Dryden
Assistant Editor: Margaret Hunanian
Contributing Editor: Henry Becker III
Photography Editor: Robert C. Bjork
Art Director: Sara Tweedie

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John R. Block, Secretary
U.S. Department of Agriculture

Anson R. Bertrand, Director
of Science and Education

Terry B. Kinney, Jr.
Acting Administrator
Agricultural Research Service

Cover: Eggs instead of chicks are inoculated against Marek's disease in a new technique that may substantially reduce losses in the poultry industry. Vaccinated as embryos, the hatched chicks will have even more resistance to the disease than chicks vaccinated when they hatch. Story on page 5. (0881X950-26)

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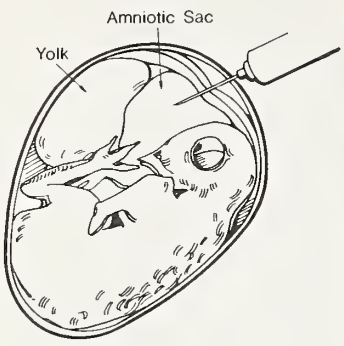
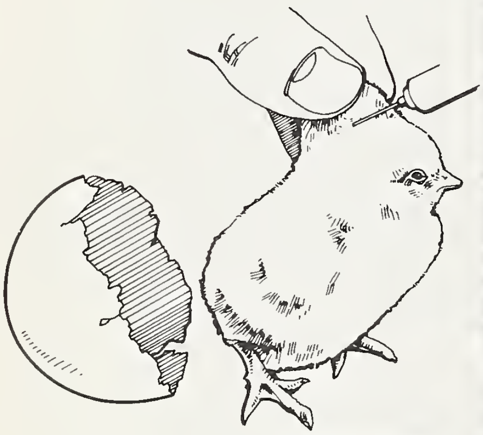
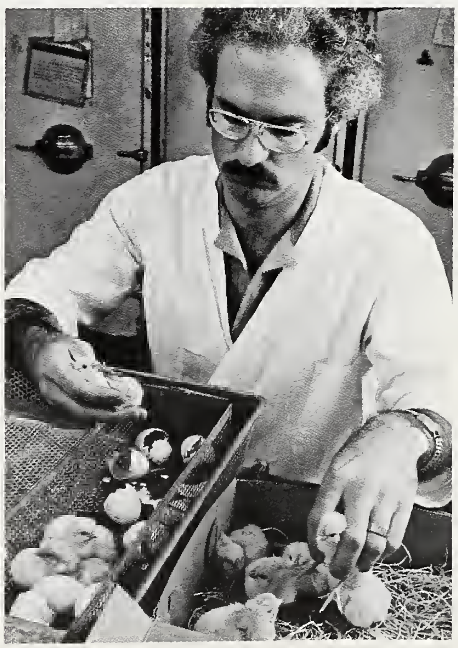


Pre-hatch inoculation



Post-hatch inoculation

In the new vaccination method (top), the needle is inserted through the eggshell into the fluid in the amniotic sac. The chick embryo receives the vaccine from this fluid. In the old method (bottom), chicks are vaccinated through the loose skin on the neck during the first day of hatch. A chick's chance of getting the disease is eight times greater with this method. (PN-6825)



Above:
Jagdev M. Sharma, veterinary medical officer, inoculates a flat of chicken eggs with HVT vaccine from the flask while laboratory technician Barry Coulson removes the next flat from the incubator for inoculation. (0881X950-22)

Left:
Barry Coulson removes a hatch of chicks vaccinated when embryos. Inoculation did not reduce hatchability. (0881X951-3)

Chicks Vaccinated Through Eggshells

Scientists have now vaccinated chicks against Marek's disease through the eggshell, demonstrating for the first time that resistance to disease can be established by that method, says Jagdev M. Sharma, ARS veterinary medical officer.

Sharma, stationed at the ARS Regional Poultry Research Laboratory adjoining the Michigan State University campus, collaborated with Ben R. Burmester in developing the technique.

"We were surprised by the results," Sharma says. "Chicks were protected from Marek's disease by the time they hatched so they overcame early exposure to the disease much better than chicks vaccinated at hatching, now the common practice in commercial production. The vaccination had no adverse effect on percent of hatch or rate of gain."

To vaccinate the embryos, a small hole was drilled in the shell and the needle inserted into the egg. The holes were then filled with paraffin, although later tests showed no ill effects from leaving the holes unfilled. After hatching, the chicks were exposed to Marek's disease by injection or by air treatment.

"This prehatch vaccination procedure may help overcome vaccination failures that are an increasing problem in commercial poultry production," Sharma says. In most commercial flocks, vaccine is injected shortly after hatching. Within a few hours, the chicks are placed in brooder houses, where exposure to Marek's disease virus is likely. The time between vaccination and exposure is sometimes so short that chicks do not develop adequate immunity, and some chicks get the disease.

To confirm this theory, Sharma put off exposing some chicks to Marek's disease until 8 days after hatching and vaccination. They were fully resistant to the virus, indicating that the vaccine and vaccination procedure were effective; the problem apparently was due to lack of time for immunity to develop after vaccination.

Sharma shows two chickens given a dose of Marek's disease virus 3 days after hatch. The chicken on top was vaccinated on the first day of hatch. The one on the bottom was vaccinated while still an embryo by the new method. (0881X951-19)

When birds vaccinated 3 days before hatching were exposed to Marek's disease by injection 3 days after hatching, they suffered 14-percent losses. Birds vaccinated the day of hatching and exposed 3 days later suffered 72-percent losses.

"We found optimum protection was achieved if vaccination was done at about the 18th day of embryonation," Sharma says, "the same time that embryonated eggs are routinely transferred to hatching trays in commercial operations. It may be possible for producers to vaccinate and transfer eggs at the same time. Whether our methods, under laboratory conditions, would be practical under commercial conditions remains to be determined. It also remains to be seen if this method of vaccination is feasible for other diseases."

Eggs used in the tests came from chickens reared in isolation, free from exposure to Marek's disease and other tumor-causing viruses as well as other bacterial and viral poultry pathogens.

Jagdev M. Sharma is located at the Regional Poultry Research Laboratory, 3606 E. Mt. Hope Rd., East Lansing, MI 48823.—(By Ray Pierce, Peoria, Ill.)

New Vaccine for Marek's Disease

A new combination vaccine for Marek's disease should protect newly hatched chicks from new, virulent strains of the disease as well as from the old strain. (0881X951-10)

A new combination vaccine that controls the more virulent strains of Marek's disease virus in chickens has been developed and tested at the ARS Regional Poultry Research Laboratory, East Lansing, Mich.

The presently used vaccine for Marek's disease was developed and released by the laboratory in 1971. It has greatly reduced losses in the poultry industry, which ran as high as $300 million per year in the United States. But the tumor-causing virus still causes annual losses of up to $100 million in this country due to mortality, reduced egg production, and condemnation at poultry slaughter plants.

Recently, excessive losses from Marek's disease have been reported in some flocks. One cause is the appearance of highly virulent strains of the virus, according to Richard L. Witter, director of the laboratory.

Witter combined two new experimental Marek's disease virus type vaccines with the vaccine made from herpes virus of turkeys (HVT), which has been in common use since 1971. Witter developed one of the vaccines by transferring a highly pathogenic field strain of Marek's disease through 75 cell culture passages to weaken the virus. The other experimental vaccine, a naturally avirulent strain of Marek's disease, came from Cornell University researchers K. A. Schat and B. W. Calnek.

Witter tested the mixture of the three vaccines on groups of chicks inoculated with one of five highly virulent strains of Marek's disease virus. The combination vaccine protected the chickens better than any single vaccine did.

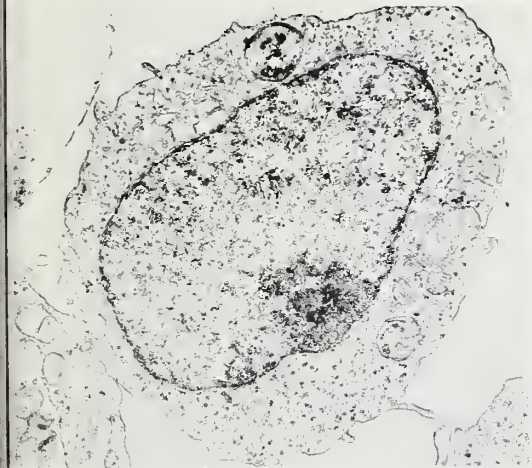
"Though these early results are preliminary, they are encouraging," Witter says. "We are now evaluating the vaccine combinations on chickens carrying antibodies that interfere with the effectiveness of vaccines."

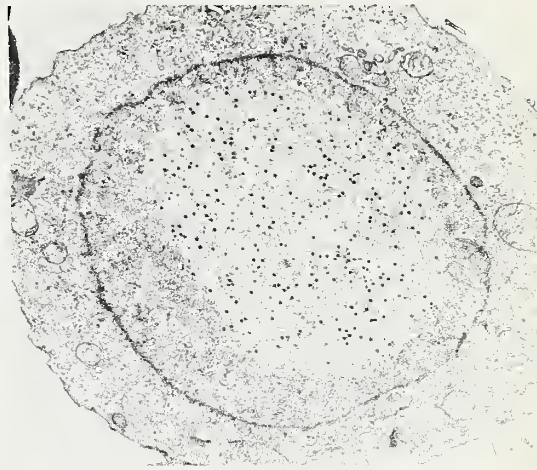
The combination of three vaccine viruses has potential for general immunization of broilers and layers against Marek's disease. In situations where the HVT vaccine is working effectively, as it is in most flocks, the combination of vaccines is not needed, Witter says. Where highly virulent strains were not controlled by the HVT vaccine, the combination of vaccines may help improve disease control.

Witter, along with Jagdev M. Sharma, plans to test the combined vaccines by vaccinating embryos before hatching. (Sharma led the effort to develop this new vaccination technique, which is described in the adjoining story.) The researchers will determine if earlier vaccination would improve the chicks' disease resistance even more.

Richard L. Witter is located at the Regional Poultry Research Laboratory, 3606 E. Mt. Hope Rd., East Lansing, MI 48823.—(By Ray Pierce, Peoria, Ill.)

Turkey Virus Grown in Culture





Left:
Electron micrograph of a normal turkey cell before infection with hemorrhagic enteritis virus (HEV). Magnification x18,000. (PN-6836).

Center:
Aly M. Fadley injects HEV from a cell culture into a turkey poult held by laboratory technician Cora Rubitschun. (0881X953-11)

Right:
Electron micrograph of turkey cell infected with HEV. Individual HEV particles can be seen as black dots in the cell nucleus. Magnification X 12,000. (PN-6837)

A turkey disease virus has been cultured outside the whole bird for the first time. This makes the virus accessible for study and manipulation in an effort to produce a vaccine.

The disease, called hemorrhagic enteritis in turkeys and marble spleen disease in pheasants and chickens, causes inflammation and bleeding in the intestine and enlargement of the spleen.

Hemorrhagic enteritis is a significant disease of turkeys, according to Daryl D. King, ARS National Program staff. It is especially troublesome in the summer, causing high levels of illness with mortality usually ranging from 5 to 15 percent in the 2- or 3-week period it takes the disease to run its course in a flock. Losses run in the millions of dollars per year in the turkey industry. The virus can also cause a serious problem in pheasant populations.

The technique for propagating the virus in cell cultures was developed by Keyvan Nazerian and Aly M. Fadly at the ARS Regional Poultry Research Laboratory, East Lansing, Mich. They used cells from spleens of infected turkey poults to infect cultured tumor cells.

After transfer to a cell culture, the virus can be observed as it grows in a new environment. It may change while growing in cultures instead of in whole birds, or it might be changed by application of genetic engineering techniques, the researchers say.

When the hemorrhagic enteritis-infected spleen material was transplanted to the cultured tumor cells the cultured cells became enlarged within 48 hours of virus infection, Nazerian says. He and Fadly detected antigens and other substances produced by the cells that reacted with the hemorrhagic enteritis virus.

When the scientists injected virus from the cell cultures into turkey poults, it caused hemorrhagic enteritis, proving that the virus was surviving in the laboratory cultures.

King says outbreaks of the disease in commercial flocks are being confined by use of crude vaccines made from extracts from infected birds, but a more uniform and reliable vaccine is needed for dependable industrywide control of hemorrhagic enteritis.

Keyvan Nazerian and Aly M. Fadly are located at the Regional Poultry Research Laboratory, 3606 E. Mt. Hope Rd., East Lansing, MI 48823.—(By Ray Pierce, Peoria, Ill.)

Photosynthesis—Learning the Limits

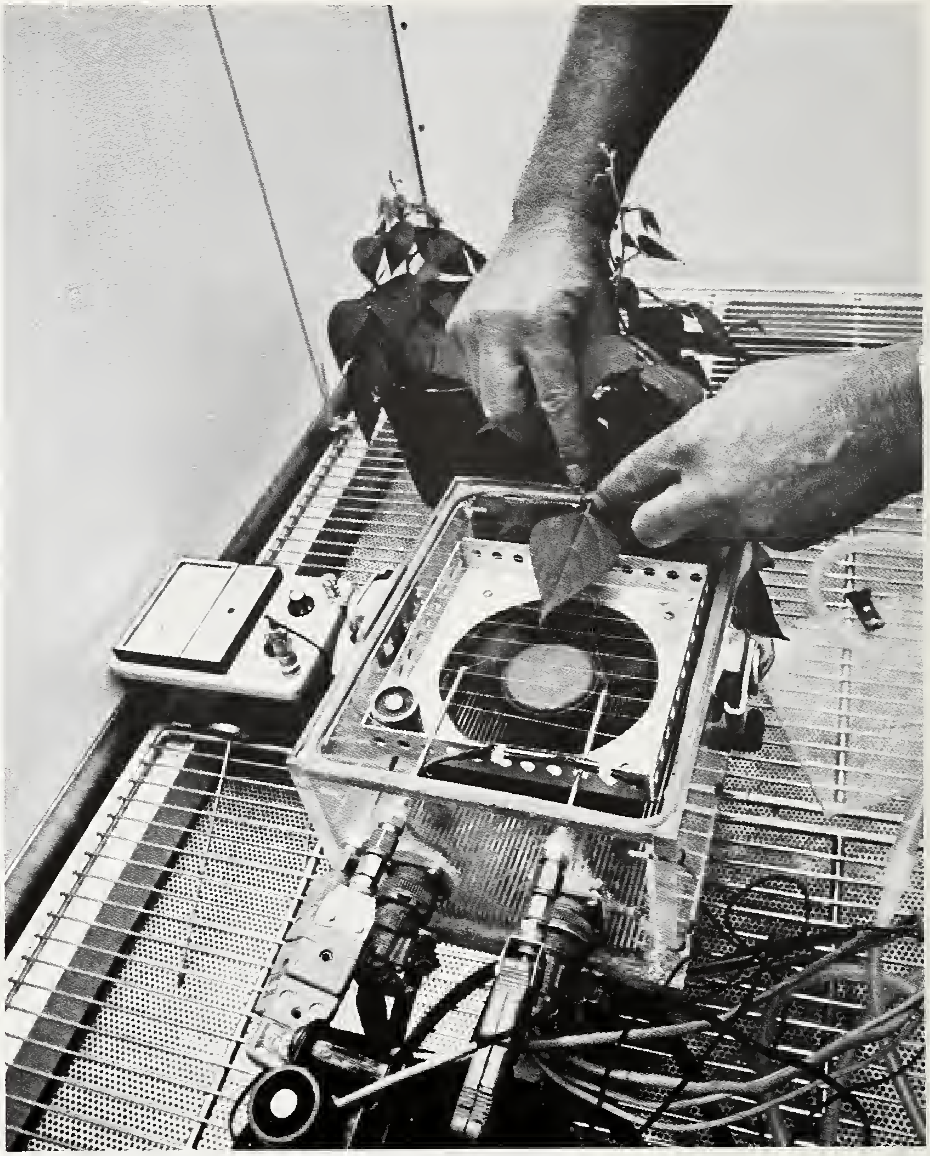
A theory to identify factors that limit photosynthesis is now being developed. If successful, the theory could one day help plant breeders select for the capacity to withstand short-term stress in developing new varieties.

Yields of plants such as sugarbeets, wheat, barley, beans, and corn are extremely sensitive to photosynthesis—the ability of plant leaves to fix, or utilize, carbon dioxide from the air. For example, in sugarbeets a 20-percent increase in average annual photosynthetic rate can boost root yields 27 percent, while a 20-percent decrease can cut yields by more than 35 percent. Photosynthesis is also the best performance barometer for many plants. Yields, of course, can be measured to assess whether a plant is performing well or poorly, but only photosynthesis can indicate whether a plant is producing at its maximum on any specific day.

Measuring photosynthesis, however, is difficult. When measuring photosynthetic rates of individual sugarbeet leaves at random under field conditions, it is not unusual for measurements to vary 30 percent around the mean. Although the reasons for much of the variation are not yet understood, some of it is caused by leaf age and short-term stress such as abrupt changes in the weather.

"If we can determine what factors in the photosynthetic process are affected by stress, it might be possible to breed or manage plants so that total seasonal photosynthesis increases and production is improved," says ARS soil scientist John W. Cary, Kimberly, Idaho.

Working with others at the Snake River Conservation Research Center and with plant physiologist Gale Kleinkopf of the University of Idaho, Kimberly, Cary is studying four factors that, individually or in combination, can limit photosynthesis. He is now developing a set of equations and experimental methods to identify which of these factors is affected under given stress conditions.



Photosynthetic rate of a bean leaf is measured in an assimilation chamber. (0981X1085-10)

The limiting factors are: the number of stomata (pores) on a leaf that are open to admit carbon dioxide; the transportation of carbon dioxide through the air spaces in the leaf and through the liquid parts of cell walls into the chloroplasts; the carboxylating enzyme in the chloroplasts that must be activated for carbon dioxide to be used; and the leaf's rate of respiration.

As with most basic and fundamental research, it will probably be a long while before plant geneticists can use this new theory to compensate for any of these four limiting factors through selective breeding. However, Cary's work to date will benefit future studies of plant-growth response to stress periods. He has shown that water evaporation, routinely used to measure leaf pore openings, sometimes suggests growth rates that are too high.

John W. Cary is located at the Snake River Conservation Research Center, Route 1, Box 186, Kimberly, ID 83341.—(By Lynn Yarris, Oakland, Calif.)

Narrow-Row Cotton Now an Advantage

Short season, once-over-harvest cotton, long sought after by growers throughout this country, comes closer to reality with the use of a narrow-row production system.

"The advantages of narrow-row cotton outweigh its disadvantages," says V. T. Walhood, ARS plant pathologist, who has been working with the system for years.

The greatest "disadvantage" in the past has been the method of picking. Narrow-row cotton is grown in 20- or 30-inch rows, while traditional rows are 38 to 40 inches apart. Most agricultural row machinery, until recently, was designed to handle 38- to 40-inch rows.

Cotton is picked one of two ways. Either spindle pickers twist off the seed cotton on rotating spindles, or stripper pickers brush the seed cotton off the plant between two rotating brushes per row—brushing off a lot of trash with the cotton.

That trash is the disadvantage of narrow-row cotton. Between 800 and 1,000 pounds of trash per bale is brushed off the plant along with the seed cotton. Present-day spindle pickers, which generate only about 50 to 100 pounds of trash per bale, are not suited to pick the narrow-row cotton, however.

"Now, though, a gin at Kings County, Calif.—using ideas out of Texas A&M University and Cotton Incorporated—has added module feeder-cleaner equipment at the gin that cleans narrow-row, stripper-picked cotton as clean as first-picked spindle. And that's using harvesters that cost about $25,000 less than spindle pickers," Walhood says.

Conventional gins are not now equipped to take out as much trash as the new feeder-cleaner equipment can, he adds. Incidentally, after going through the new cleaner, "once-over" stripper-picked cotton appears to generate no more dust in the mill than first-picked spindle.

Eliminate the trash disadvantage, Walhood says, and you have a cotton production system that "we have found produces cotton equal to or better in grade than first-picked spindle." In addition, the system has several other advantages:

- It aids in pink bollworm management because it allows growers to terminate the crop early. After harvest, the crop can be plowed down before the pink bollworm is prepared for overwintering, much earlier than the date set by state regulations. "Pinkies" overwinter in any available late-season bolls. In September and October they must have squares, flowers and bolls as food sources to prepare them for the overwintering generation.
- It improves secondary pest management. Less spraying for pink bollworm allows predators of the tobacco budworm and bollworm to build up and help control those pests.
- It improves late-season pest management—that same buildup of predators helps control the aphids, whiteflies, and bollworms that usually hit the crop late in the year.
- It aids in verticillium wilt management by allowing the crop to escape late-season devastation by the disease.
- It benefits the environment by limiting use of chemical pesticides.
- It reduces growers costs for harvest and for pesticide, water, and fertilizer use.
- It reduces soil compaction, and it allows more time for double-cropping.

The narrow-row system uses up to 25 percent less water than conventional cotton and about half of the nitrogen. It matures from 1 to 3 months earlier than conventional cotton, Walhood says.

It gins slightly more slowly than conventional cotton because of the extra trash, but the thousands of pounds of trash can be turned into an extra energy source, he says.

Narrow-row cotton's popularity in California began in the early 1970's, when 500 acres were grown. Since then the acreage has steadily increased—1,000 acres in 1977, 5,000 in 1978, 10,000 in 1979, and 20,000 in 1980. Estimates are that about 25,000 acres were planted in 1981.

In one yield study designed for pink bollworm management, Walhood harvested 210 pounds per acre more lint in narrow rows than in conventional rows (1,260 vs. 1,050 pounds) by August 24.

In November, the narrow-row system produced 1,881 pounds, compared with 1,568 in 40-inch rows. Cotton in the Imperial Valley, where the study was made, normally is harvested from November 1 to January 15. Average yield at that time is about 1,500 pounds per acre.

V. T. Walhood is located at the U.S. Cotton Research Station, 17053 Shafter Ave., Shafter, CA 93263.—(By Paul Dean, Oakland, Calif.)

Sugarbeet Irrigation Cut Without Sucrose Loss

Overhead sprinklers irrigate a field of sugarbeets. An irrigation system that maintains sucrose yield but uses substantially less water is welcome news for the sugarbeet industry, where cuts in production costs are sorely needed. (Photo courtesy of Grant Heilman.)

It's been suspected for quite a while now that many crops are overirrigated, a costly luxury at a time when water for irrigation is becoming limited and expensive. An ARS soil scientist has proven that sugarbeets are routinely overirrigated, and his findings hold bright implications for a beleaguered U.S. sugarbeet industry.

John N. Carter at ARS's Snake River Conservation Research Center, Kimberly, Idaho, working with Del J. Traveller, an agronomist with the Amalgamated Sugar Co., Twin Falls, Idaho, has demonstrated that very little if any sucrose yield is lost when sugarbeet irrigations are discontinued after August 1—about 3 months early—providing that the soil profile is filled with water when irrigation is cut off.

This means that sugarbeet production costs in irrigated areas could be cut substantially. For an industry perched on the economic borderline between profit and loss, this is good news.

In their 2-year study to learn the effects of mid- to late-season water stress on sugarbeet growth and yield, Carter and Traveller grew sugarbeets under normal irrigation until August 1, and then limited water on some of their test plots. Periodically during each growing season, they measured sucrose concentration, sucrose yield, plant nitrogen uptake, and leaf growth. After harvest at the end of October, the researchers measured total sucrose production.

"Sucrose production was scarcely affected, even when we used only 70 percent of the total irrigation water normally applied in the course of a growing season," says Carter.

"Before discontinuing irrigation," he says, "the soil profile should be filled with water to a depth of 64 inches, and the available soil water should be equivalent to at least 8 inches.

Left:
Deficit water management would allow growers to eliminate late-season irrigation of mature sugarbeets like those shown here. (Photo courtesy of Grant Heilman.)

Below:
Research has shown that late-season water stress increases sucrose concentration in beet roots. (Photo courtesy of Grant Heilman.)

"During dry years, it may be advantageous to apply a light irrigation about 1 month after the water cutoff," he adds. "Also, the soil should be wet enough at harvest to prevent roots from breaking."

Even in water-short years, when no irrigation water is available after August 1, and plants are subjected to severe mid- to late-season water stress, Carter says sucrose production can be maintained at sufficient levels to make harvest profitable.

"However," he warns, "if a full soil water reservoir is used by one season's crop and winter rainfall does not replenish the reservoir for the succeeding crop, then a preplant irrigation may be needed the following season."

The use of this reduced irrigation technique, called "deficit water management," during August, September, and October curtails leaf growth and reduces leaf area no longer needed. It also reduces nitrogen uptake, increases sucrose concentrations in the beet root, and decreases fresh root yield. Fresh root yield decreases are caused by root dehydration.

In addition to cutting down on the irrigation costs and water needs, mid- to late-season deficit water management also lowers hauling costs of beets by decreasing the water content of the harvested roots. Root quality is improved by the lower water content and the higher sucrose concentration.

Carter says that more research is needed to determine if dehydrated beets can be successfully stored in piles and if there is any reduction in the extractability of sucrose from these roots.

John N. Carter is located at the Snake River Conservation Research Center, Route 1, Box 186, Kimberly, ID 83341.—(By Lynn Yarris, Oakland, Calif.)

A Better Way to New Seedless Grapes

New seedless grape varieties, like these freshly harvested Thompson grapes, can be developed sooner by crossing seedless varieties with each other. (Photo courtesy of Grant Heilman.)

New varieties of seedless grapes are being developed by a process called ovule culture.

Seedless grapes are not truly seedless. They have traces of seeds with the traces in some varieties larger than in others.

The ovule culture process could dramatically speed up development of new varieties, increase the efficiency of variety development, and increase the likelihood that resultant plants would be seedless.

"Grape breeding is a numbers game," says David W. Cain, former ARS horticulturist in Fresno, Calif., now with Clemson University, who worked with ovule culture. "The more seedlings you look at, the greater the chances of finding one that has all the characteristics needed for a new commercial variety.

"The present method used to develop new seedless varieties like 'Flame Seedless'—released by USDA in 1973—involves pollinating a desirable seeded female parent with pollen from a seedless male parent. It's an inefficient process since about 80 percent of the offspring are discarded because they produce seeds," Cain says.

In most seedless grape varieties, the ovules—"eggs" that when fertilized by pollen later become seeds in seeded varieties—abort early in their development. These stunted ovules, barely detectable by consumers, remain tiny while the fleshy part of the berry continues to grow, resulting in, for all practical purposes, a seedless grape.

What Cain is trying to do is prevent the abortion of the ovules by removing them from the grapes before they abort. He then places the immature ovules in an artificial culture medium—food source—where they develop into seeds. So far he has succeeded in obtaining plants from two seedless varieties.

"Plants grown from ovules have a greater chance of being seedless than from the old pollination method," Cain says.

"The exciting aspect of this technique is that it allows grape breeders to hybridize seedless varieties with each other. This not only allows us to make crosses which were previously impossible, but also should result in a much higher frequency of seedless offspring. The increase in efficiency will greatly increase our chances of finding new commercially acceptable table and raisin grape varieties," Cain says.

David W. Cain is located at the Department of Horticulture, Clemson University, Clemson, SC 29631.—(By Paul Dean, Oakland, Calif.)

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